FIGURE I — LOCATION OF OIL AND GAS TESTS LISTED IN TABLE I

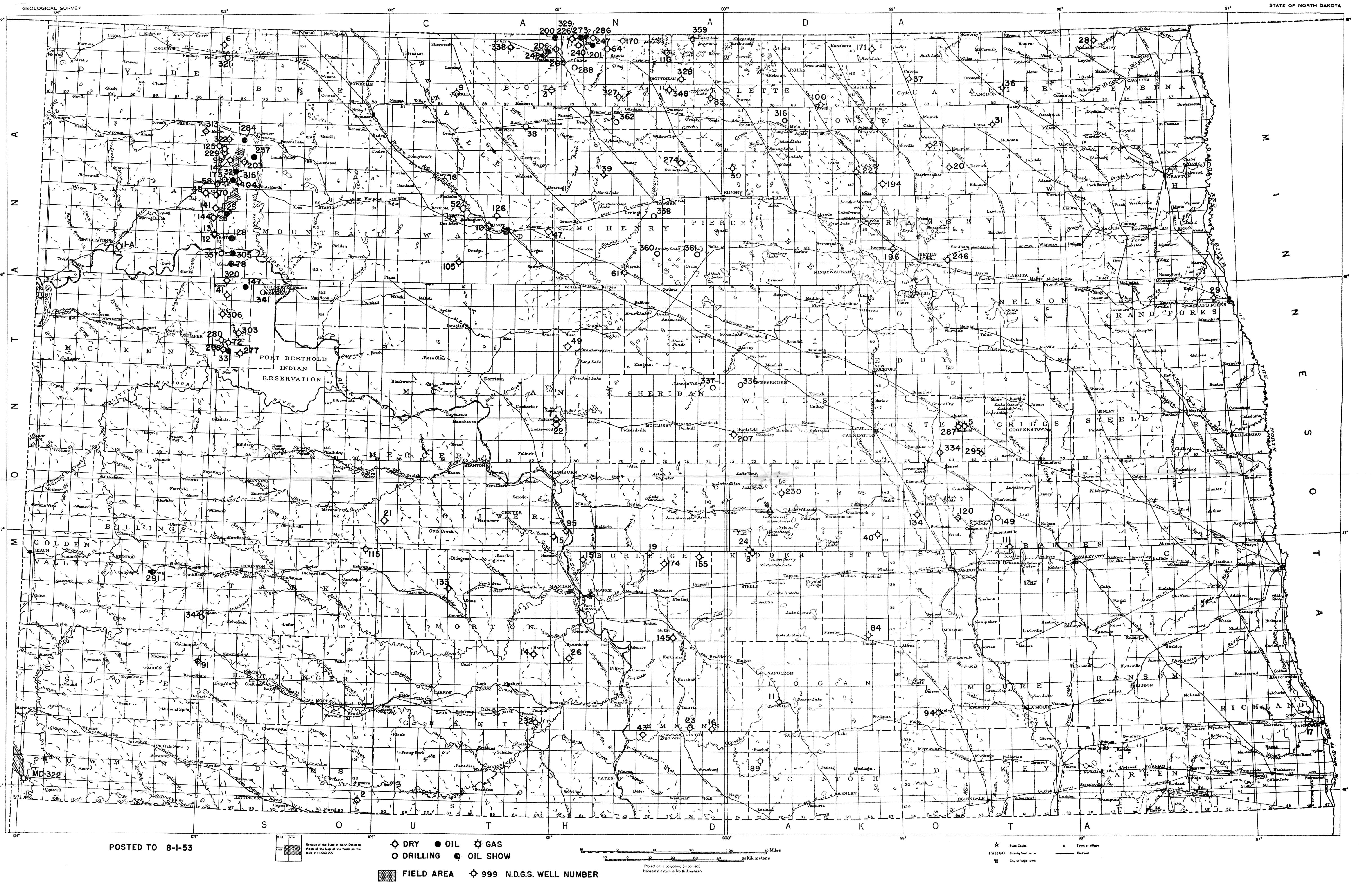

TABLE I — DATA ON SIGNIFICANT TESTS FOR OIL AND GAS IN NORTH DAKOTA

Well Number*	Operator	Well Name	Location	County	Elevation	Total Depth										Date Completed	Surface Rocks	Rocks in Hole at Bottom	Remarks
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
207	Continental	Smith #1	NENE27-140N,73W	Wells	1933KB	6031	2492	440	113	40	127	792	459	261	1096	1953	Pleistocene	Pre-Cambrian	D & A
295	Evans	Bailey #1	SWNE20-145N,62W	Foster	1491gr	2050	1692	20	0	0	0	76	52	111	919	1953	Pleistocene	Pre-Cambrian	D & A
316	Evans	Johnson #1	SWSW23-160N,70W	Rolette	1643	4942	1961	539	76	0	0	229	957	347	531	1953	Pleistocene	Pre-Cambrian	D & A
MD-322	Montana-Dakota	#322	SE 6-129N,106W	Bowman	2917	1371	1371+							-	-	1946	U. Cretaceous	Eagle sand.	Gas well in Eagle sand, typical of gas wells on Little Beaver Dome.

*The numbers used in this chart and on the map are those used by the Survey to identify North Dakota wells and are the same as those used in N.D.G.S. Circular 5 "Well Data and Tops of Significant Wells".

Note #1: Amerada Iverson #1 plugg & back to 10,530'. Initial production July 1951. Flowed 290 BOPD 39.8° API 10,490' - 10,530' (U.Devonian) Tested oil and gas at 11,630 - 11,[illegible] (Silurian).

STRATIGRAPHY OF NORTH DAKOTA WITH REFERENCE TO OIL POSSIBILITIES

By

WILSON M. LAIRD AND DONALD F. TOWSE

Introduction

The information contained on the accompanying charts and maps is self-explanatory. It is being presented in this form for the use of those interested in the geology of the State, particularly those interested in the accumulation of commercial quantities of oil and gas. Any conclusions drawn in this report should be regarded as tentative.

The subsurface stratigraphy of the state is just beginning to be understood. In some critical areas no wells have been drilled, and the data from the many recent wells have not been completely analyzed. Records of the older wells are not good, and records of the elevation and formations of many of the deep water wells in southeastern North Dakota are lacking. This revision incorporates information from wells drilled in the last year and one half. The maps have been brought up to date, and the stratigraphic information has been revised.

General Structure

The Tertiary Williston Basin reflects a major structural feature that has existed in North Dakota since early Paleozoic time. The general outline of the basin can be seen in Figure 13, where the shape of the basin is shown by contours drawn on the top of the Cretaceous Dakota sandstone. It will be seen that the deepest part of the basin is in McKenzie and Dunn Counties, and that the basin becomes shallower gradually in an easterly direction and more rapidly in a westward direction from this area. It also rises northwestward and southeastward.

This basin is what Kay[1] would term an autogeosyncline, described as having " . . . non-detrital carbonates and salines, and detritus from low near-by land and from orogenic mountains in a distant orthogeosynclinal belt; stratigraphic units generally converge gradually from the center or axis of the deposit." It will be seen by comparing Figures 3 thru 12 that this area has not always been a site of extensive deposition during the Paleozoic and Mesozoic. It was most active as an area of downsinking and accumulation of sediments during the Ordovician, Devonian and Mississippian of the Paleozoic era. During the Mesozoic, particularly during the Cretaceous, the area was even more active and large amounts of sediments were deposited. The convergence and thinning of the beds taken into consideration along with the possible overlap and off-lap conditions of sedimentation make the edges of this basin interesting for possible stratigraphic type traps for the accumulation of oil. The gentler dip of the eastern side of the basin and its relationship to the old land area to the east should make that side of the basin particularly attractive to the oil prospector.

The Nesson anticline in northwestern North Dakota is represented as a southerly plunging anticlinal nose on the generalized structural map of the Dakota sandstone.

Surface studies[2] and subsurface mapping show that the structure is more complex. The Beaver Lodge field contains several separate structural highs, and the Mississippian axial line lies northwest of the Cretaceous and Jurassic axial lines. Nevin's work shows that the south end of the Nesson anticline is a dome with some surface closure.

In addition to the Nesson, there are other fairly well-known structures in the state. Two domes near Linton in Emmons County, North Dakota have been penetrated by two wells, namely the Northern Ordnance Franklin Investment Number 1 (No. 16 on Figure 1) and the Roeser and Pendleton J. J. Weber No. 1 (No. 23 on Figure 1).[3] These structures differ from others in the state in that their trend is nearly east-west.

Some interesting speculations on the origin of these east-west or northeast-southwest structures can be made, but little positive data is available. The geologic map or the tectonic map of the United States shows that the strike of Pre-Cambrian rocks in Minnesota is northeast-southwest. It does not require much imagination to extend those trends under the younger rocks into the subsurface in North Dakota.

Recent ground magnetometer survey by the North Dakota Geological Survey[4,5] suggest northeast-southwest trends of some type in the basement rocks.

The folds in Minnesota are the result of late Pre-Cambrian folding which undoubtedly affected the North Dakota area as well. Those folds must have been base levelled in Pre-Ordovician time and the Cambrian and the Ordovician sea undoubtedly advanced over the old-land area. Some of the erosion remnants may have extended some distance above the general level and thus may be the "core" over which later sediments were deposited. Thus some of these east-west and northeast-southwest folds may be due to Pre-Cambrian highs, and a magnetic study of the eastern half of the state, where the sediments are thinner and where such structure might be more easily detected by a magnetometer, might be a profitable venture.

It should be emphasized that the foregoing hypothesis is based on very little positive evidence and that it should be used only as a possible guide to exploratory thinking.

Other smaller anticlines in Emmons County parallel in general the trend of the Cedar Creek anticline, and this is true of other structures known in the state, especially those in the southern part of Morton County, North Dakota.[6]

Among the structures which might be found are those of the fault type. Several fault type structures are questionably identified in the state although the exact origin of these is not entirely clear. The dip is about 45° to the north and east in beds of Fox Hills or Cannonball age in a range of hills near Horsehead Lake in Kidder County. The dip is directly opposite from the regional dip. It has been suggested that the attitude of these beds may be due to ice shove, although it seems unlikely that a disturbance of this magnitude might have occurred in that area.

About seven miles north of Carberry in Bottineau County on the west side of the Turtle Mountains is an area of disturbed Fort Union rocks. That disturbance, however, is apparently due to ice shove or landslide.

Recently Townsend[7] described a small structural disturbance in the northwestern part of state near Lignite in central Burke County. He has indicated that the structures so noted are due to structural deformation. The exact nature of this deformation must await further detailed work.

The origin of these structures is still a matter of conjecture. The parellelism of the major portion of the anticlines with the Cedar Creek anticline suggests orogenic folding. It seems hard, however, to imagine that these structures are due to compression or horizontally-directed forces transmitted through such incompetent beds as those of the Cretaceous and the overlying Cenozoic.

It is possible, however, that some of these folds may be due to compaction of beds over hard cores at depth. More possibly, they might be due to compaction over reefs which are known to be present in the Devonian or over Pre-Cambrian highs as mentioned previously. This is, however, something which would be difficult to prove at present, and it is hard to see how much compaction features would show through such a large unconformity as is present at the base of the Triassic and Jurassic in North Dakota.

One hypothesis which should be given consideration is that some of these folds may be due to deep-seated faulting. The western side of Cedar Creek anticline is by far the steeper, and some geologists suggest that faulting actually extends to the surface on the western side at the north end. P. F. Lyons[8] states that the Cedar Creek anticline is due to basement faulting on the basis of geophysical evidence. It is suggested, therefore, that some of the anticlines that are found in North Dakota may be due to deep-seated faulting in the basement rock.

If the folds are due to deep-seated, high angle faulting, there would be less necessity for the folds to be closely aligned. There might be cross folds at angles to the general Cedar Creek structural trend. This cross faulting to the general trend is suggested by the questionable fault structure in Kidder County near Horsehead Lake and by the east-west trending anticlines in Emmons County.[9] The Keene Dome of the Nesson anticline in McKenzie County suggests a split axis.[10] If that fold were due to deep-seated faulting, the split axis might be due to a cross fault.

Stratigraphy

The diagrammatic maps shown in Figures 3-12 portray the approximate extent of the various systems in North Dakota as they are known at the present time. In some cases the present outlines of the systems probably mark the approximate extent to which they were originally deposited, while in others the shorelines were prabably far from the position shown on the maps.

The Cambrian (Figure 3) extends only a short distance into the state. In the Carter N. P. No. 1 well in Fallon County, Montana, it consists of " . . . interbedded green shale and dolomite overlying a basal glauconitic sandstone."[11] There is the possibility as indicated in Figure 3 that the Cambrian may extend much farther into North Dakota depending on the age determination of the highly glauconitic sand at the base of the Winnipeg formation.

The Ordovician (Figure 4) is one of the most extensive Paleozoic systems in the state. It is known primarily from the samples of wells in the central and eastern part of North Dakota. Ehlers[12] has given a description of the lithology of the Ordovician in the Carter Semling well. At the base is the Winnipeg formation consisting of 521 feet of green shale and interbedded glauconitic sandstone and some sandy limestone. Some of the sand is conglomerated and some is poorly cemented and fine-to coarse-grained. In the Northern Ordnance well in Emmons County the same formation consists of green shale with some limestone in the upper part and mainly poorly-cemented sand with some shale in the lower part. In the Northern Ordnance well the sandstone carried abundance water under considerable pressure. That water was relatively fresh and had 2607 parts per million total dissolved solids. The entire section except for a few shale stringers had fair to good porosity and should provide an excellent reservoir rock for oil when found under the proper conditions. Small oil shows were reported in Hunt's Kleven well and Continental's Duemeland well in Burleigh County.

The Red River formation lies above the Winnipeg formation. The Red River formation varies from 100 to 640 feet thick and consists largely of white to very pale orange or pinkish gray limestone and dolomite. The lower part of the formation is more shaly, and the upper part is fragmental and porous. Some oil stain has been noted.

Oil is produced from the Red River formation in several places on the Cedar Creek anticline in eastern Montana.

The Stony Mountain formation at the top of the Ordovician system consists of two members, a lower shale member and an upper Gunton member. The Stony Mountain shale member contains gray, green, and red shales and streaks of gray fossiliferous limestone. In well cuttings usually only the limestone is found, and bryozoa are the most apparent fossils. The shale member is easily recognized on electric logs and in samples, whereas the Gunton member may be hard to distinguish. The shale member is used as a key bed, and the Gunton member is often not differentiated from the overlying Silurian. The Gunton member is light colored sugary dolomite. The Stony Mountain formation is from 0 to 200 feet thick.

The Silurian Interlake group covers all but the eastern edge of North Dakota. The Interlake consists of white to very pale, sugary to lithographic dolomite with some coral and stromatoporoid beds. Reddish brown shales are common, and the base is sandy. The Interlake group is from 0 to 1200 feet thick. Amerada's Clarence Iverson No. 1 discovery well tested high gravity oil and large quantities of gas in the top of the formation.

Distribution of the Devonian system is similar to that of the Silurian; the thickest section is in the northwestern part of the state. The Devonian in North Dakota is similar to that of Saskatchewan and Manitoba, although some thickness and facies differences are present.

Formal discussion of the Devonian system is made difficult by the confusion in nomenclature. Most workers are in substantial agreement on a major breakdown into lithologic units, but new names are used without definition of type area and unit boundaries, and in some cases names well established in the literature have been superseded in field usage without regard to proper stratigraphic procedure. New names proposed by the A.A.P.G. Williston Basin Committee on Nomenclature and Correlation for previously unnamed formations will be used in this discussion within quotation marks. If a valid name is available, it will be used followed by the new name in parentheses.

The Ashern formation is at the base of the Devonian. It is 0 to 50 feet of red to pale orange shaly dolomite and shale, and it consists of weathered Silurian sediments re-worked by the advancing Middle Devonian Sea.

The Elm Point formation lies between the Ashern below and the Winnipegosan above. It is 0 to 225 feet of dense mottled to fine shaly gray limestone and dolomite.

The Winnipegosan ("Winnipegosis") is 0 to 250 feet of pinkish light gray and pale brown granular to fragmental porous dolomite. It contains at the top a thick evaporite and shale unit, the "Prairie evaporite", that has been considered a separate formation and may be as thick as 300 feet or may not be present at all. The "Prairie" is thicker in Saskatchewan. Reefs are developed at the Manitoba outcrops of the Winnipegosan. The "Prairie evaporite", Winnipegosan, Elm Point, and Ashern taken together constitute the Elk Point group.

The Manitoban ("Dawson Bay") formation above the Winnipegosan contains 0 to 200 feet of light olive to yellowish gray sugary dolomite and limestone, shale, anhydrite, and small amounts of sand. The Manitoban and older Devonian units belong to the Middle Devonian. The exact Upper-Middle Devonian boundary is uncertain, but it is probably at or a short distance above the top of the Manitoban formation.

The "Souris River formation" is 0 to 300 feet of light gray to yellowish gray shaly and anhydritic limestone and dolomite. The "Souris River" and Manitoban formation constitute the "Beaverhill Lake group", and it is tentatively correlated, at least in part, with the Beaverhill Lake formation of Alberta.

The "Duperow formation" above the "Souris River" is 0 to 425 feet of light-colored sugary limestone and dark brown crystalline dolomite, with some dolomite, anhydrite, and shale. It produced oil in the discovery well at Beaver Lodge in Williams County.

The "Nisku formation" above the "Duperow" is 0 to 125 feet of yellowish gray to dark brown crystalline limestone. The "Nisku" has good large vugular porosity. A thin green shale at the base is considered a possible equivalent of the Ireton shale of Alberta. Oil shows were reported in the "Nisku" in Amerada's Herman May No. 1 well in Billings County. No oil was recovered on drill-stem test. The "Nisku" and "Duperow" have been called the "Saskatchewan group."

The Lyleton formation ("Three Forks") is the youngest Devonian formation. It contains 0 to 190 feet of red, pink and moderate orange dolomitic shale, silt, dolomite, and some anhydrite.

All Devonian formations thicken basinward, and there are accompanying changes in facies.[13] The Middle and Upper Devonian are not co-extensive, in that only Middle Devonian is known on the Manitoba outcrop, and in northwestern Montana only Upper Devonian rocks are present. The extent of the two series in eastern and southern North Dakota is imperfectly known, but the onlap pattern of the Upper Devonian is known to be complex. The distribution of the Devonian and Mississippian systems is irregular near their eroded edges, as in northeastern North Dakota and southern Manitoba.

The Mississippian system has much the same distribution as the Devonian, except that it doesn't extend quite so far east. See Figure 7. The basal formation is the Kinderhookian Englewood formation, carbonaceous shale, gray limestone, gray shale, silt, and fine sandstone as much as 110 feet thick. The Englewood is a good gamma log marker, and the fine sandstone in the Tioga field has some light oil stain. The rocks are generally tight, however, and no production has been developed in them. The Englewood is considered to be the equivalent of the Englewood limestone in the Black Hills. It was called the "Bakken formation" by the A.A.P.G. Williston Basin Committee.

The Madison group consists of, in ascending order, the Lodgepole, limestone, the Mission Canyon limestone, and the Charles formation. The Lodgepole, of probable Kinderhook and Osage age, is gray to yellowish brown granular to crystalline limestone and shaly limestone and gray shale. Porosity is usually poor, and the Lodgepole may be as much as 880 feet thick.

The Mission Canyon limestone is 0 to 530 feet thick and contains granular to oolitic very pale yellowish brown, light gray, and very pale orange limestone. The Mission Canyon produces oil in eastern Montana and in the fields on the Nesson anticline in North Dakota. The Mission Canyon is probably Osage and Meramec in age.

The Charles formation is pale yellowish brown and brownish gray dolomite and limestone, varicolored shale, and anhydrite as much as 890 feet thick. The base of the Charles is usually considered to be at the base of the last thick anhydrite bed, but the contact with the Mission Canyon below is gradational. The Charles is Meramec and Chester in age, and it has produced oil at Richey and East Poplar in eastern Montana and in Bottineau County in North Dakota.

The Kibbey formation, the basal formation of the Big Snowy group as originally defined, is a red and white variegated-colored shale sequence with considerable poorly sorted sandstone at the base. It is 0 to 350 feet thick and has produced oil on the Ragged Point structure in Central Montana.

The Otter formation is a variegated-colored shale which is hard in the subsurface to separate exactly from the overlying Heath. On the surface in the type area in Montana it is characterized by a brilliant green color.

The Heath formation is largely a black carbonaceous shale with small amounts of limestone and dolomite and green shale. In the type area in Montana the Heath is petroliferous and produces small amounts of oil in central Montana.

The Heath, Otter, and Kibbey make up the Big Snowy group, considered to be Chester in age. The formations are often hard to separate, but the dark shale and high gamma activity of the Heath make it a good marker, and the top of the Charles is distinctive.

The Amsden formation above the Big Snowy group contains as much as 250 feet of pink and light purple dolomite, dark shale, brown shale, and small amounts of sandstone. The Amsden is believed to belong to the Mississippian in North Dakota, but in Wyoming the upper part is Pennsylvanian. Some consider the Amsden in North Dakota both Mississippian and Pennsylvanian in age or a partial equivalent of the Pennsylvanian Minnelusa.

The extent of the Pennsylvanian and Permian in North Dakota is uncertain. Both systems are present in southeastern Montana and southwestern North Dakota. Some would extend the systems over much of the State, but the data for such a correlation are at present inadequate. The Pennsylvanian Minnelusa formation consists of 300 feet of white to reddish sandstone and shale, gypsum, and dolomite in Fallon County, Montana.[14]

The Permian system includes the Opeche formation, 88 feet of red shale and anhydrite below, and the Minnekahta formation at the top, 40 feet of pink to purple dolomite and limestone.

The Triassic Spearfish formation (See Figure 10) consists of brick-red, medium-to fine grained sandstone, red and gray silty shale, some gray and black shales, and gypsum. The formation is 130 feet thick in the Phillips-Carter well, and it is missing in the Roeser and Pendleton Weber No. 1 in Emmons County.

The Jurassic system (Figure 10) includes the Ellis group and the Morrison formation. The Piper, as much as 350 feet thick, is the lower part of the Ellis and is brown and gray shale, gypsum, and limestone at the top. A thick limestone at the top is a good marker bed. The limestone has some porosity but has not produced oil to date.

The Sundance formation, the upper part of the Ellis, contains as much as 650 feet of green, gray, and brown shale, limestone, and sandstone. Some of the sandstones are glauconitic, and their porosity makes them potential reservoirs.

The Morrison formation at the top of the Jurassic system is 0 to 265 feet of gray and green non-marine shale and sandstone. The Morrison and Sundance belong to the Upper Jurassic series and the Piper belongs to the Middle Jurassic. No Lower Jurassic is known in the State. The base of the Jurassic seems to be gradational with the Triassic Spearfish.

The basal sandstone and shale unit of the Cretaceous system and shale is the Cloverly or "Dakota" group. The Cloverly is correlated with the Cloverly of Montana and the Inyan Kara group of the Black Hills, but due to the transgressive nature of the basal Cretaceous the ages are not exactly the same in different areas. The Lakota sandstone at the base is 20 to 190 feet of coarse white sandstone with some shale. It is separated from the Dakota sandstone by the Fuson shale, as much as 150 feet of gray shale, sandy shale and sandstone. The Dakota sandstone at the top of the group is 100 to 300 feet of micaceous white sandstone with pyrite, gypsum, and lignite. When the Fuson is absent or very sandy the three-fold formational division is not used. Small amounts of gas have been produced from Cloverly sandstones in southeastern North Dakota, but no commercial production has been developed. The sandstones are quite porous.

The Benton shale above the Cloverly is 90 to 1360 feet of medium to medium dark gray marine shale. Two members within the Benton are good marker beds. The "Muddy sand" is as much as 90 feet thick and lies about 200 feet above the Cloverly. "The Muddy" is a variable unit of fine white sandstone and silty shale. The sandstones thin eastward toward the center of the state, but other sandstones are present on the eastern edge. The "Muddy sand" member is tentatively correlated with the "Muddy" and Newcastle of Wyoming on the basis of stratigraphic position, but continuity and time equivalence have not been demonstrated.

The Greenhorn limestone member, about 450 feet above the "Muddy" is a speckled gray calcareous shale and limestone unit about 100 to 150 feet thick. Small gas shows have been reported, and the Greenhorn has occasionally some fine sandstone. The Greenhorn in North Dakota may be traced with reasonable certainty from the Black Hills.

The Benton is both Upper and Lower Cretaceous. The series boundary must lie somewhere between the "Muddy sand" and Greenhorn, because recent paleontological work has established the Lower Cretaceous age of the Mowry shale of Wyoming,[15] which lies in a position between the "Muddy" and the Upper Cretaceous Greenhorn.

Overlying the Carlile is the Niobrara formation, which consists of from 80 to 215 feet of gray calcareous shale with very calcareous shale or "cement" rock at the top. The Niobrara is known at the surface in the Pembina Mountains in North Dakota as well as along the Sheyenne River in North Dakota in the central part of the state. In the "cement" rock part of the formation are a number of Foraminifera, notably *Globigerina*. The zones containing the *Globigerina* are sometimes called the "white speckled zones", and there appear to be several such in the Niobrara. Whether or not these zones can be used as marker beds is not yet fully determined due to lack of study. The Benton shale and the Niobrara together are the Colorado group.

Overlying the Niobrara is the Pierre shale, which is from 930 to 2300 feet thick. It is an extensive gray shale sequence and is not particularly fossiliferous. At the base of the Pierre outcrop in the northeastern part of North Dakota in the Pembina Mountains is a bed which is known as "Fuller's earth", probably a badly leached bentonitic shale. Whether this bed can be found in the subsurface is not known, although there is some indication that it may be. It has been traced on the surface at the Pembina Mountains far north into the Riding Mountains and even farther north into Manitoba. At the upper part of the Pierre and near the base of the Fox Hills is a concretionary zone which is more or less transitional to the basal part of the Fox Hills formation. This concretionary zone is frequently very fossiliferous, especially with *Discoscaphites* and *Inoceramus*.

The Fox Hills sandstone overlies the Pierre and records the last great Cretaceous inundation of the continent. It consists largely of gray glauconitic sandstones and interbedded greenish-gray marine shale. In thickness it varies from 180 to 320 feet and in the central part of the state its outcrops are best known in the area around Linton.[16] It is also found on the east side of the Baker-Glendive anticline in the western part of Bowman County, southwestern North Dakota. The Fox Hills and Pierre make up the Montana group.

Overlying the Fox Hills is the Hell Creek formation,[17] the youngest Cretaceous formation found in North Dakota. The Hell Creek is a continental sequence consisting mainly of fine-grained shaly sandstones, lignitic shales, and some thin lignites. In thickness it varies from 100 to 575 feet. One member of this formation is of interest because it indicates the transitional nature of the contact between the Fox Hills and the overlying Hell Creek. In the central part of Morton County and in the northern part of Sioux County is the small marine Brien member. That member marks a very minor marine incursion immediately after the beginning of Hell Creek time. It is apparently only an estuarine type of deposit and probably marks a readvance from the "Fox Hills sea" to the south.

The Hell Creek formation is characterized by non-marine fossils, notably the remains of the dinosaur *Triceratops*.

The Tertiary system is represented in North Dakota by the Paleocene, Eocene, and Oligocene series. See Figure 12. The Paleocene is represented by the formations of the Fort Union group.[18,19] The lowest of these is the Cannonball formation which consists of a sequence of gray to buff marine sandstones and gray shales. This intergrades with and is equivalent to the Ludlow formation to the west. The Ludlow is a sequence of brown lignitic shales. The thickness of both these formations runs about 300 feet. Overlying the Cannonball-Ludlow is the Tongue River formation which consists of 250 to 850 feet of gray fine-to medium-grained sandstones, lignites, lignitic shale, and gray shales. All of the Tongue River beds are of non-marine origin and are the main lignite-producing formation of the state.

The Eocene Golden Valley formation consists of fine-grained, micaceous sandstones with minor amounts of light-colored shales and clays. The basal part of the formation is a sequence of hard white to dark-gray clays and local lignites. The middle part of the basal sequence is frequently yellow mottled on weathering making this bed an excellent markerbed where exposed. The formation is approximately 150 to 200 feet thick.

The Oligocene White River formation contains terrestrial conglomerates, coarse-to fine-grained calcareous sandstones, and shales and is exposed in isolated buttes in southwestern North Dakota.[20] Some limestones of fresh-water origin are also known locally. The formation is 100 to 200 feet thick.

The northern and eastern parts of the state are covered by varying quantities of glacial drift. The only part of the state not extensively covered lies south and west of the Missouri River. In the drift area the thickness varies from nearly nothing to several hundred feet.

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FIGURE III—CAMBRIAN

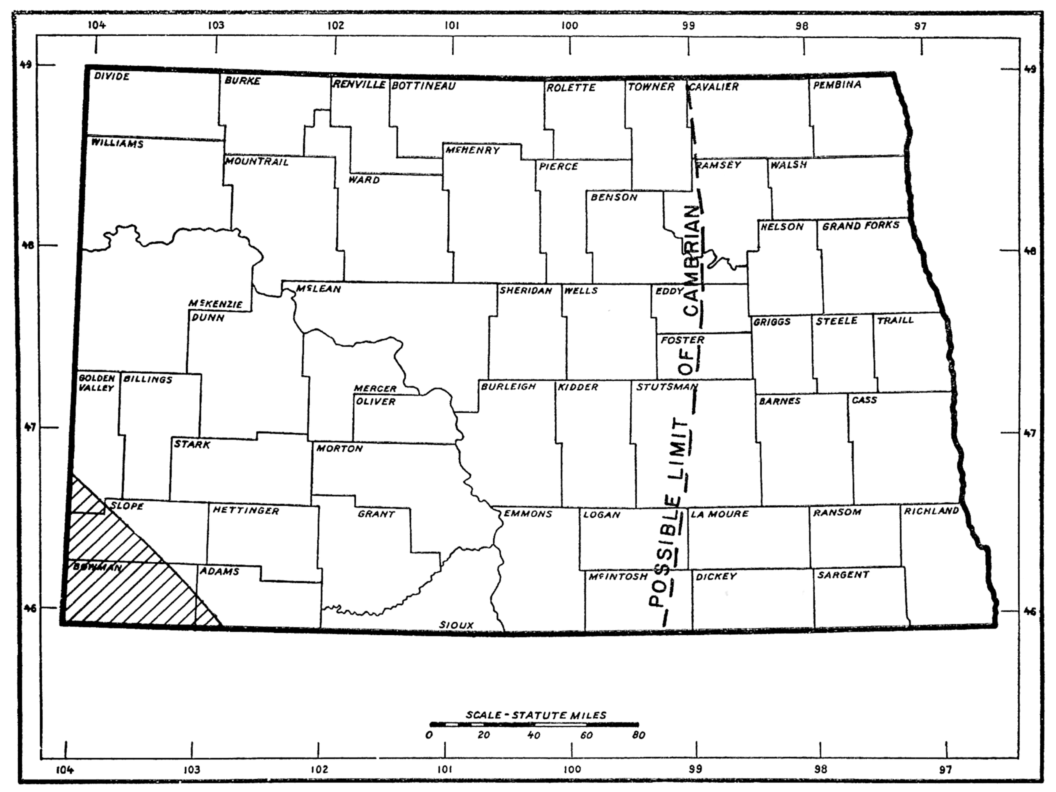

FIGURE IV—ORDOVICIAN

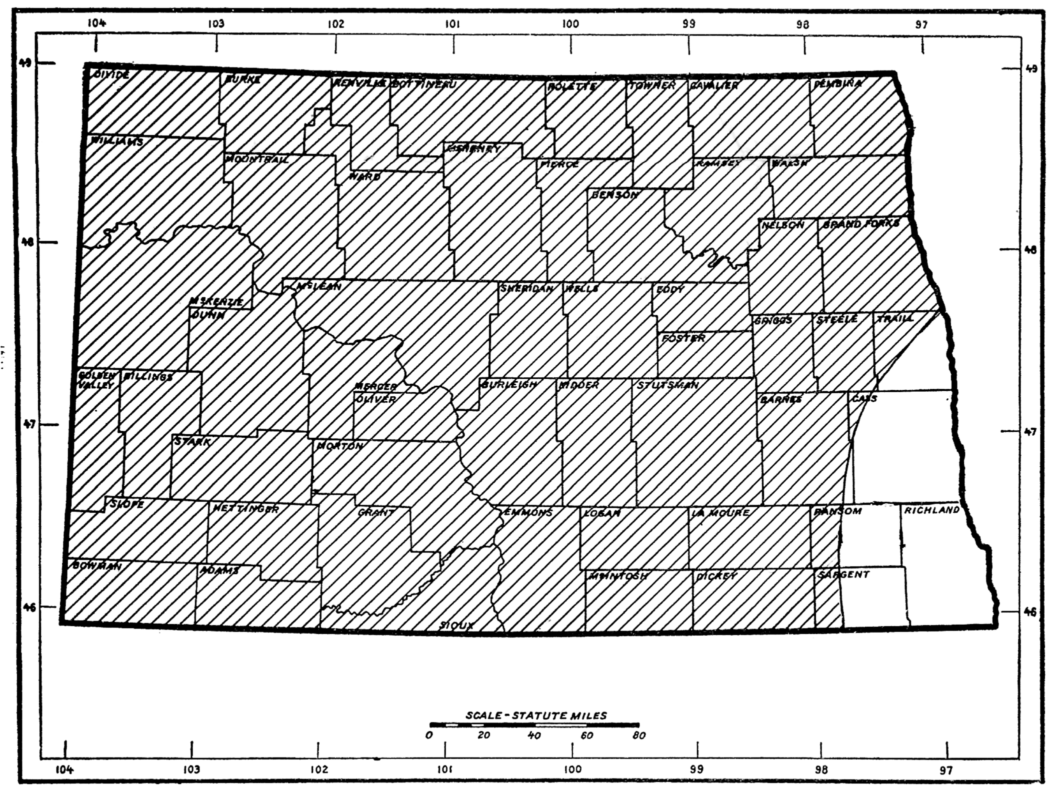

FIGURE V—SILURIAN

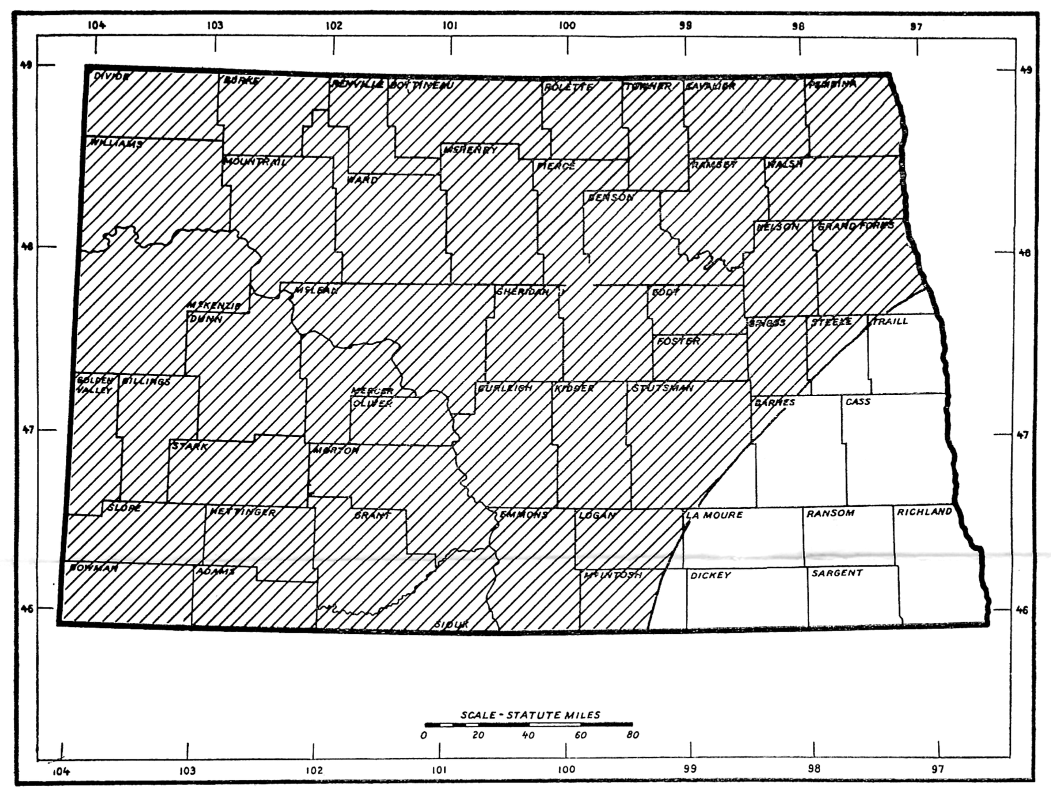

FIGURE VI—DEVONIAN

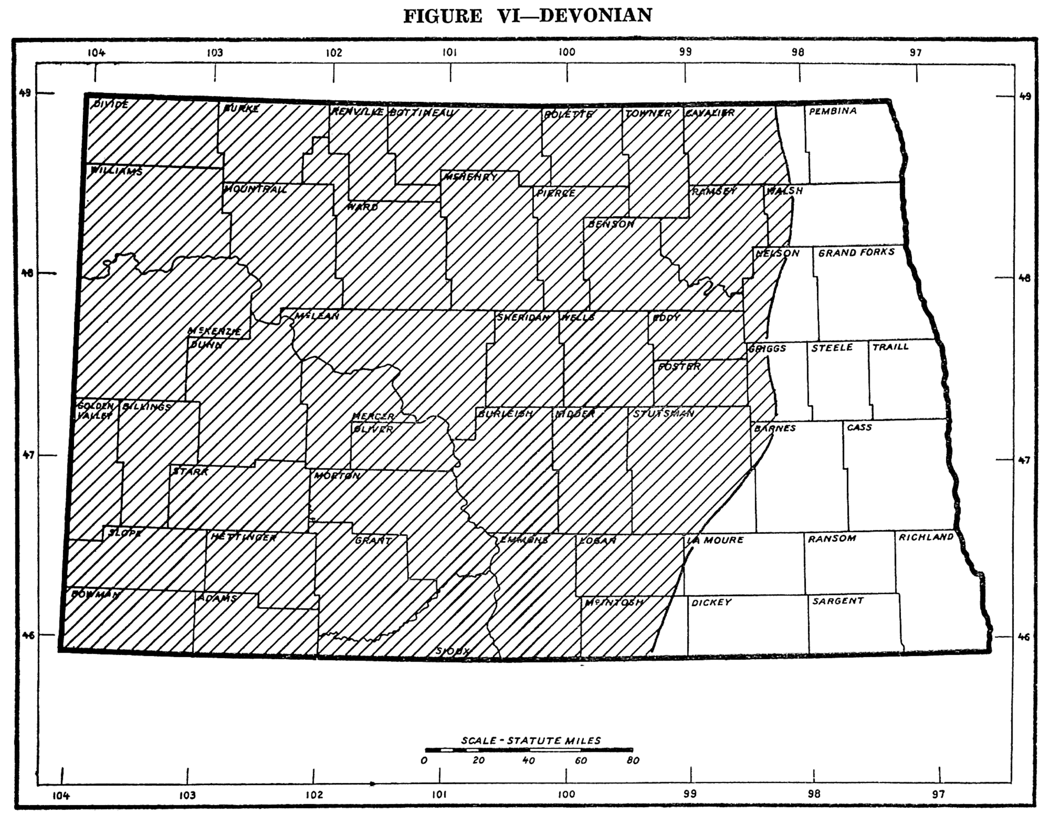

FIGURE VII—MISSISSIPPIAN

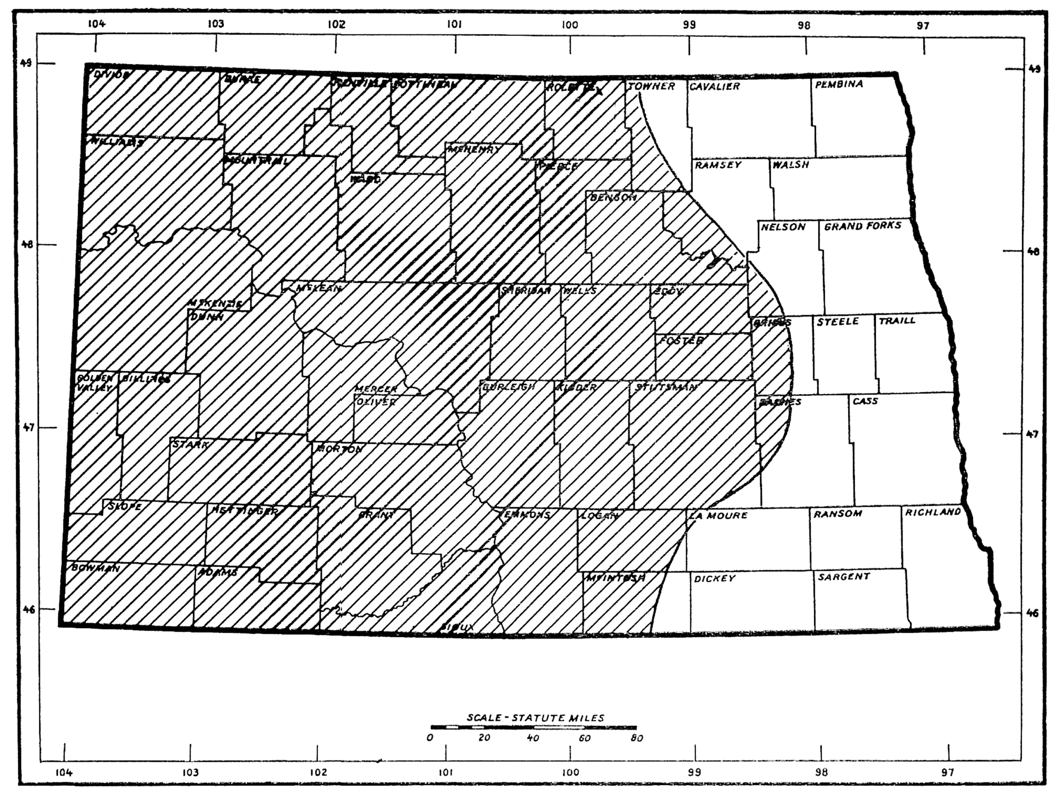

FIGURE VIII—PENNSYLVANIAN

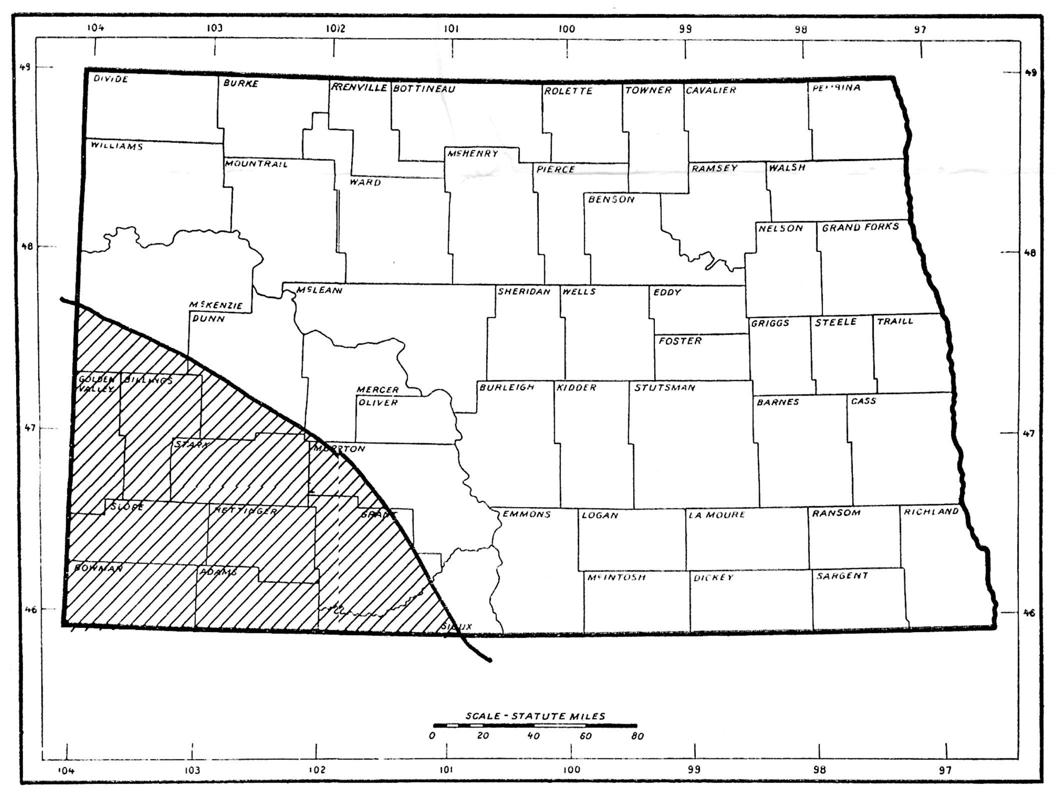

FIGURE IX—PERMIAN

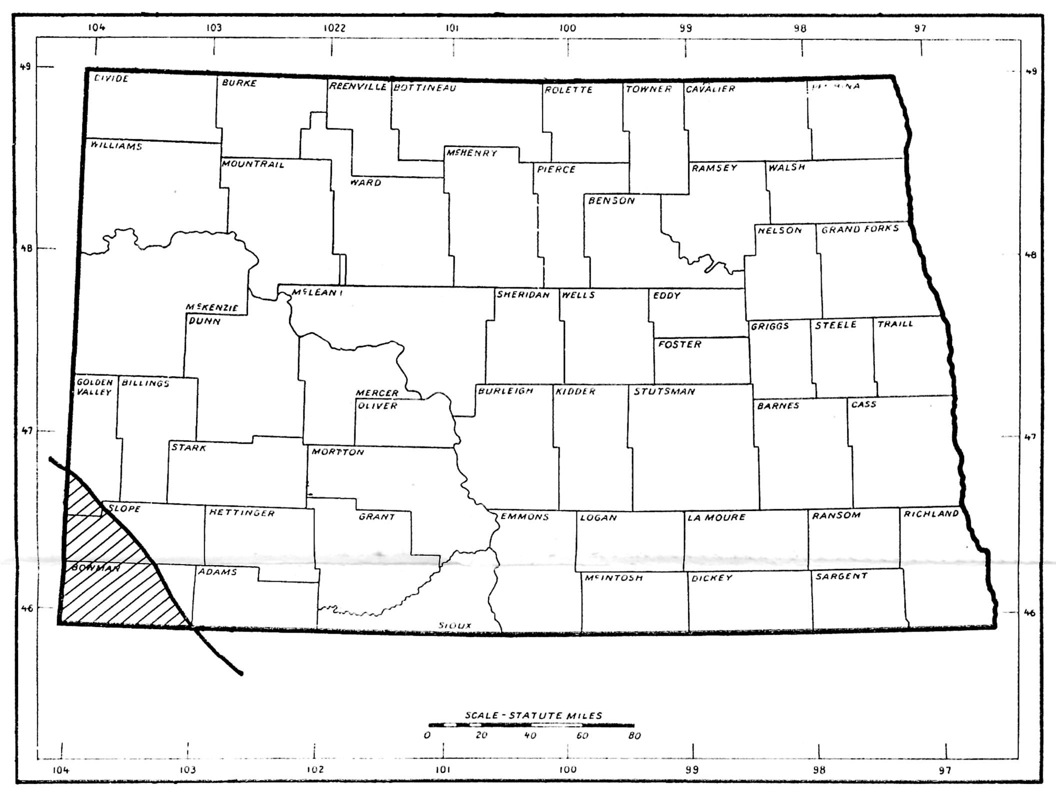

FIGURE X—TRIASSIC-JURASSIC

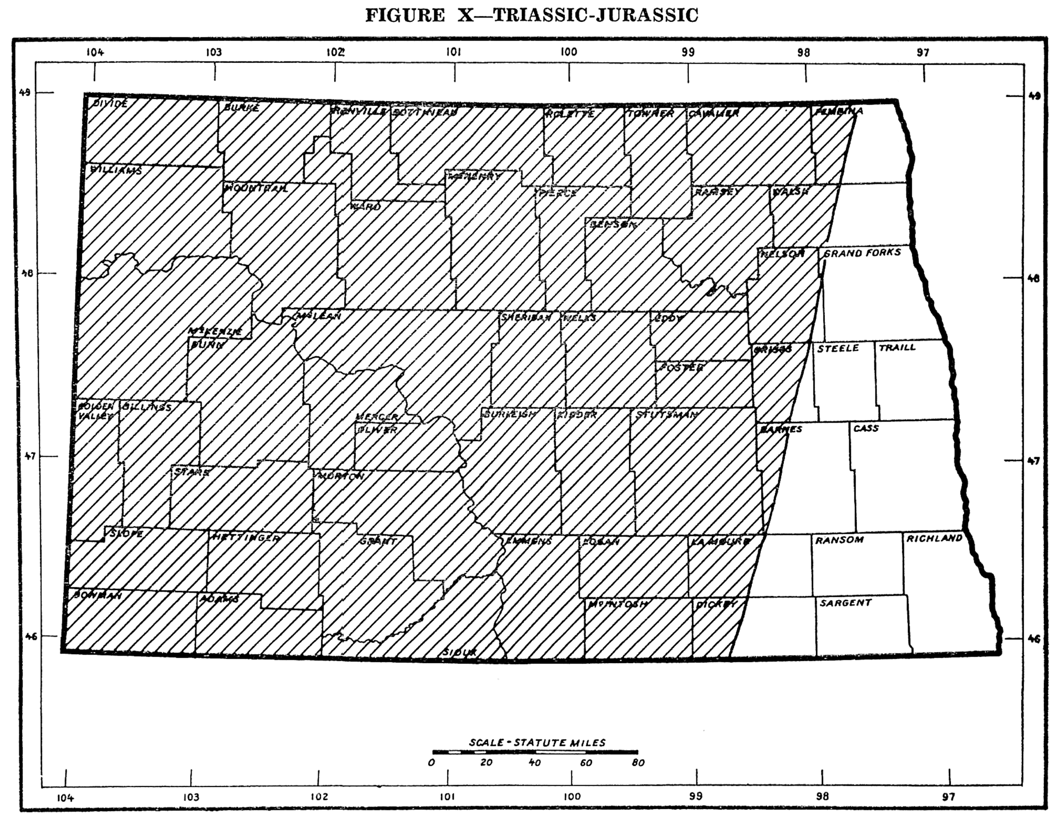

FIGURE II—EAST-WEST CROSS SECTION

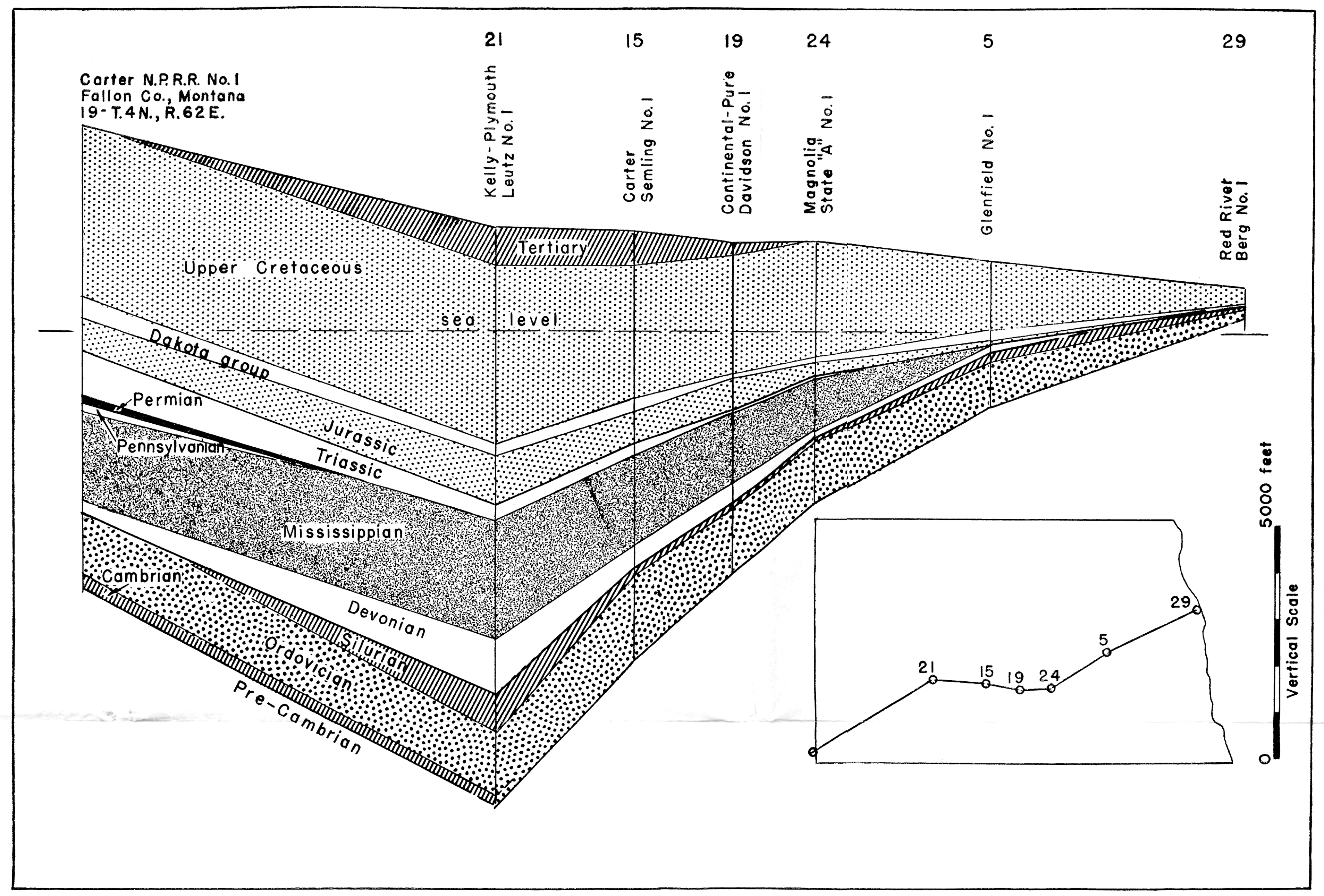

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FIGURE XI—CRETACEOUS

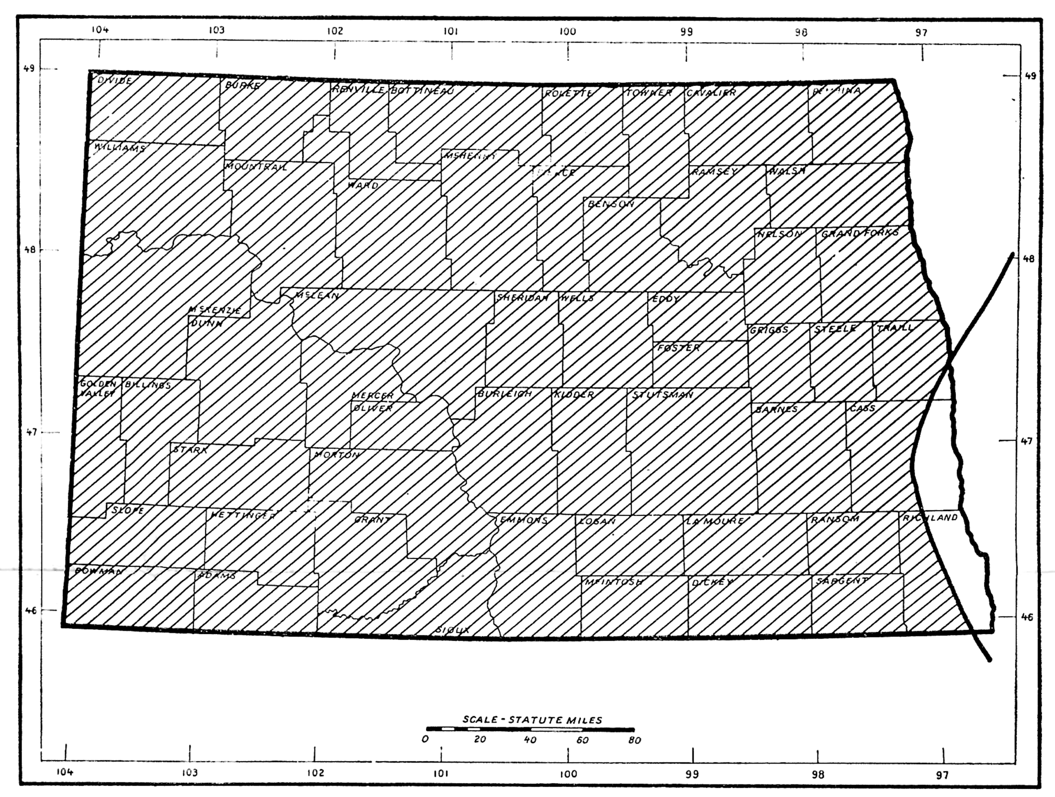

FIGURE XII—TERTIARY

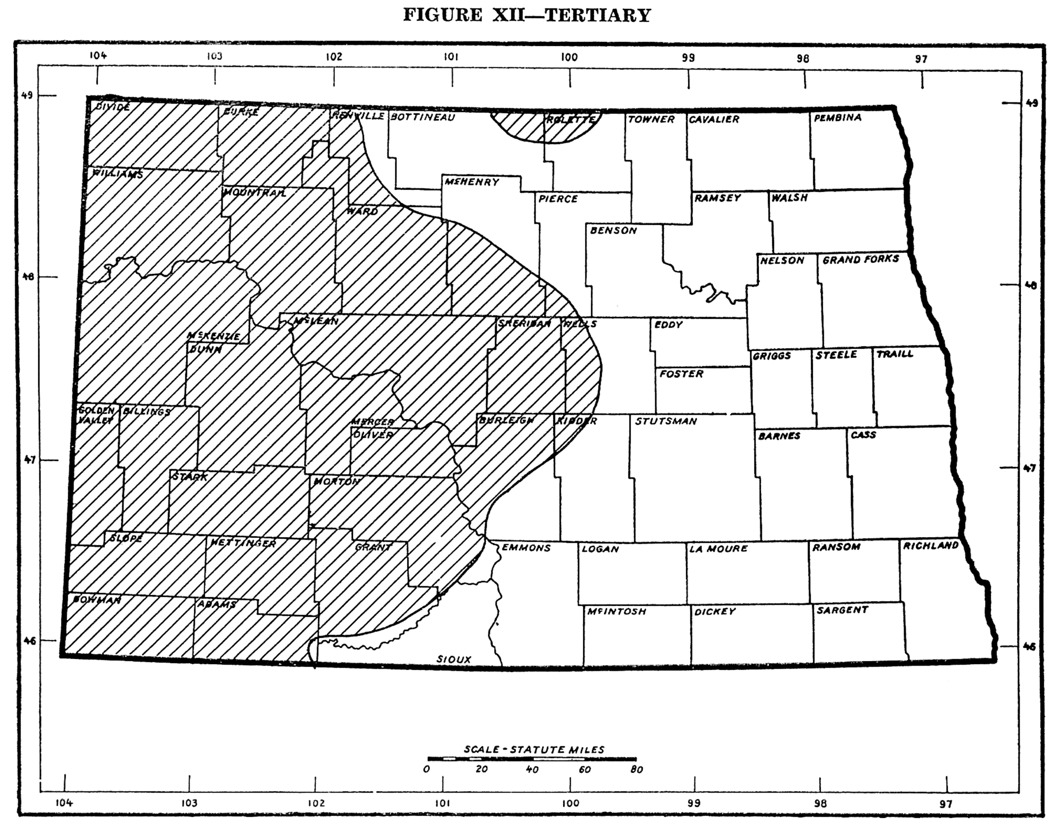

TABLE II—GEOLOGIC FORMATIONS OF NORTH DAKOTA

Table II. Geologic Formations in North Dakota

Era	System	Series	Group	Formation
CENOZOIC				Surficial Pleistocene moraine, lakebed, delta, outwash deposits. 0-500 feet.
	Tertiary	Oligocene		White River formation. 50-200' clays, shales, limestone, sandstone.
	Tertiary	Eocene		Golden Valley formation. 100-200' light-colored clay, ash, sandstone.
	Tertiary	Paleocene	Fort Union group	Tongue River formation. 200-800' light-colored and dark-colored calcareous shale and sandstone and lignite.
	Tertiary	Paleocene	Fort Union group	Cannonball formation. 0-360' marine sands, clays; Ludlow formation. 0-250' lignite, shale, and sandstone where Cannonball marine beds are present.
MESOZOIC	Cretaceous	Upper		Hell Creek formation. 100-575' gray bentonitic sandstone and shale, lignitic shale and concretions.
	Cretaceous	Upper	Montana group	Fox Hills sandstone. 180-320' brown to gray sandstone with ironstone concretions.
	Cretaceous	Upper	Montana group	Pierre shale. 930-2300' medium to medium light gray shales and ironstone concretions. Gas production from Eagle sand at Little Beaver dome.
	Cretaceous	Upper	Colorado group	Niobrara formation. 80-215' medium to medium light gray calcareous and speckled shale and "cement rock".
	Cretaceous	Upper	Colorado group	Benton shale. 90-1360' medium to medium dark gray shale with bentonite. Includes Greenhorn limestone and "Muddy sand" members.
	Cretaceous	Lower	Cloverly "Dakota" group	Dakota sandstone. 100-300' micaceous white sandstone with pyrite, gypsum and lignite. Artesian water in southeast.
	Cretaceous	Lower	Cloverly "Dakota" group	Fuson shale. 0-150' gray shale, sandy shale, and sandstone. Where Fuson shale is absent, separation of Dakota and Lakota not attempted.
	Cretaceous	Lower	Cloverly "Dakota" group	Lakota sandstone. 20-190' coarse white sandstone with little shale.
	Jurassic	Upper		Morrison formation. 0-260' gray and green non-marine shale, sandstone.
	Jurassic	Upper	Ellis group	Sundance formation. 0-650' green, gray, brown shale, sandstone, small limestone.
	Jurassic	Middle	Ellis group	Piper formation. 0-350' brown, gray shale, gypsum. Dense limestone at top.
	Trias.			Spearfish formation. 0-900' moderate to light brown silty shale, brown to reddish orange sandstone, gypsum, anhydrite.
PALEOZOIC	Permian			Minnekahta formation. 40' pink, purple dolomite, limestone. Southwestern N. Dak.
	Permian			Opeche formation. 0-88' red shale, anhydrite. Southwestern N. Dak.
	Penn.			Minnelusa formation. 0-300' white, reddish sandstone, shale, gypsum, dolomite Southwestern N. Dak.
	Mississippian	Chester		Amsden formation. 0-250' pink, light purple dolomite, dark shale, brown shale, small sandstone.
	Mississippian	Chester	Big Snowy group	Heath formation. 0-335' dark carbonaceous shale, gray to green shale, dolomite. Gamma log marker.
	Mississippian	Chester	Big Snowy group	Otter formation. 0-310' gray, green, light brown shale, and anhydrite.
	Mississippian	Chester	Big Snowy group	Kibbey sandstone. 0-350' gray to light brown shale, olive to pink sandstone at base.
	Mississippian	Osage-Meramec	Madison group	Charles formation. 0-890' pale yellowish brown and brownish gray dolomite, limestone, varicolored shale, anhydrite. Oil production in Bottineau County.
	Mississippian	Osage-Meramec	Madison group	Mission Canyon limestone. 0-530' granular to oolitic very pale yellowish brown, light gray, and very pale orange limestone. Oil and gas production at Beaver Lodge.
	Mississippian	Osage-Meramec	Madison group	Lodepole limestone. 0-880' gray, yellowish brown, granular to crystalline limestone and shaly limestone, gray shale.
	Mississippian	Kinderhook		Englewood formation. 0-110' carbonaceous shale, gray limestone, gray shale. silt and fine sandstone. Gamma log marker.
	Devonian	Upper		Lyleton formation. 0-190' red, pink, moderate orange dolomitic shale, silt, dolomite, anhydrite.
	Devonian	Upper	"Saskatchewan group"	"Nisku formation." 0-125' yellowish gray to dark brown crystalline limestone, vugular.
	Devonian	Upper	"Saskatchewan group"	"Duperow formation." 0-425' light-colored sugary limestone and dark rown crystalline dolomite, anhydrite, shale. Produced oil in Beaver odge field.
	Devonian	Upper	"Beaverhill Lake group"	"Souris River formation" 0-300' light to yellowish gray shaly and anhydritic limestone and dolomite.
	Devonian	Upper	"Beaverhill Lake group"	Manitoban formation ("Dawson Bay"). 0-200' light olive to yellowish gray sugary dolomite and limestone, small sand, shale, anhydrite.
	Devonian	Middle	Elk Point group	"Prairie evaporite" 0-300' Anhydrite, red to brown shale, salt, dolomite. May be top member of Winnipegosan formation. Western N. Dak.
	Devonian	Middle	Elk Point group	Winnipegosan formation ("Winnipegosis") 0-250' Pinkish light gray and pale brown fine to granular and fragmental porous dolomite.
	Devonian	Middle	Elk Point group	Elm Point formation. 0-225' dense mottled to fine shaly gray limestone and dolomite.
	Devonian	Middle	Elk Point group	Ashern formation. 0-50' red to pale orange dolomitic shale or shaly dolomite, anhydrite.
	Silurian			Interlake group. 0-1200' very pale orange and pink sugary to lithographic dolomite. Small shale, sandstone. Niagaran-Alexandrian in age. Produced oil and gas at Beav r Lodge.
	Ordovician	Upper		Stony Mountain formation. 0-200'. Gunton member at top is light colored sugary dolomite. basal Stony Mountain shale memb. is red, green, gray shale, with gray fossiliferous limestone.
	Ordovician	Middle		Red River formation. 0-600' v ry pale orange to pinkish gray dense to granular dolomitic and sandy limestone.
	Ordovician	Middle		Winnipeg formation. 0-550' gray, greenish gray shale, white and glauconitic sandstone, small gray limestone.
	Camb.			Deadwood formation. Green shale, dolomite, glauconitic sandstone. Distribution uncertain.
PRE-CAMBRIAN. Granite, granite gneiss, amphibolite schist.				

FIGURE XIII—STRUCTURE MAP OF DAKOTA SANDSTONE